Atomistic theory of excitonic fine structure in $InAs_xP_{1-x}$/InP nanowire quantum dot molecules

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In this work we present theoretical study of electronic and optical properties of realistic nanowire quantum dot molecules. We utilize atomistic tight binding combined with the configuration interaction method [1,2]. We used this approach for calculations of realistic nanowire quantum dot molecules formed by double alloyed $InAs_xP_{1-x}$ disk-shaped nanowire quantum dots embedded in InP nanowire grown in [111] direction. Chemical composition of these nanostructures varies from idealistic, pure InAs to $InAs_{0.2}P_{0.8}$ i.e. similar to experimentally grown nanostructures where the quantum dot is heavily intermixed with the barrier material.

Our results indicate that for pure InAs quantum dots there is spontaneous localization of single particle states in one of nominally identical InAs double quantum dots forming a nanowire quantum dot molecule, which is mediated by strain and origins from the lack of the vertical inversion symmetry in [111] nanostructures of overall C_{3v} symmetry [3].

Next, we focus our attention on the fine structure splitting and optical properties of light and dark excitonic states in alloyed (x=0.5 and x=0.2) nanowire quantum dots. We show that lowering of symmetry due to alloy randomness triggers nonzero excitonic fine structure and the dark exciton optical activity [3].

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